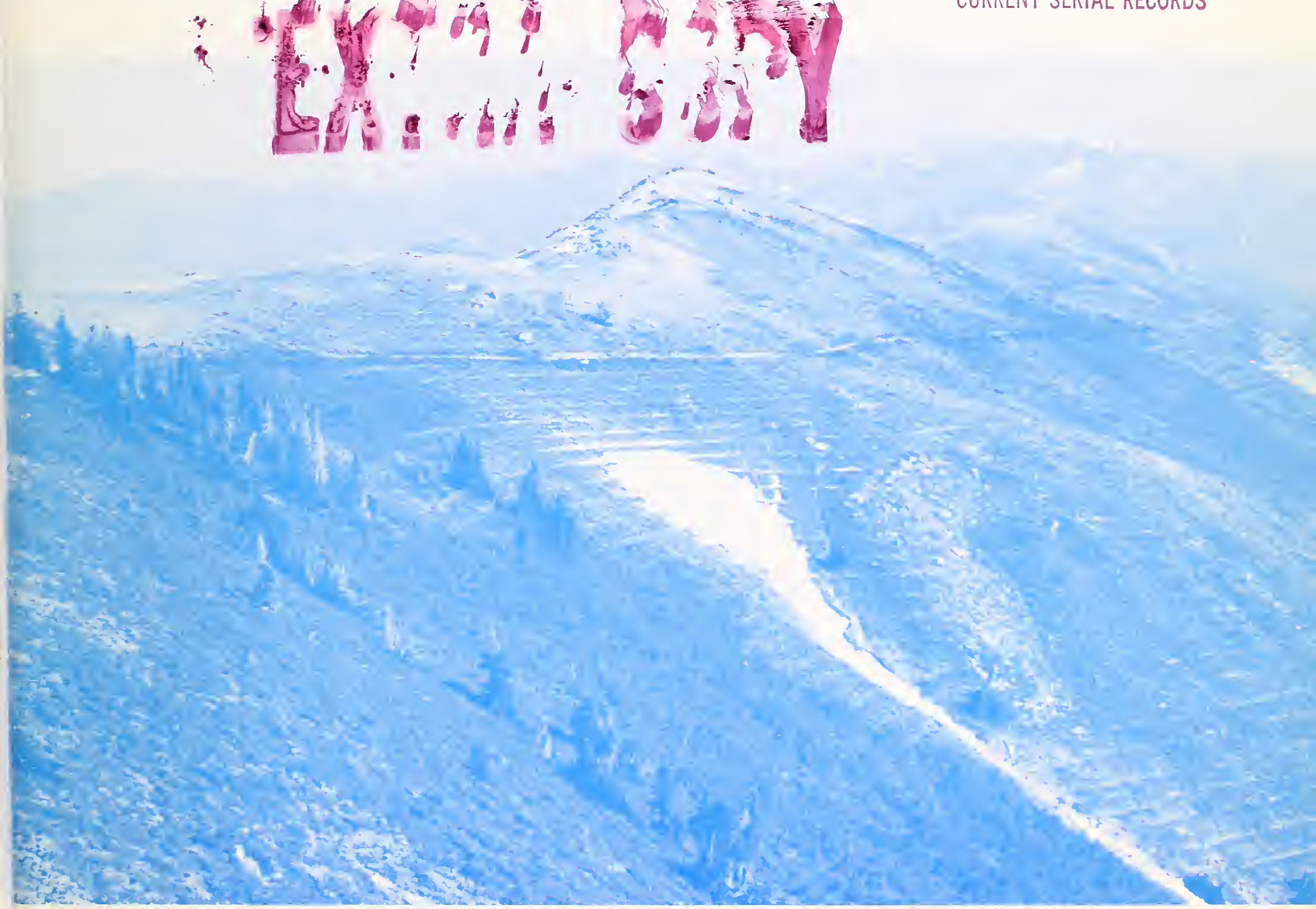
Research Related to the Davis County Experimental Watershed: An Annotated Bibliography

Compiled by
Norbert V. De Byle and Ezra Hookano, Jr.



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INTERMOUNTAIN FOREST AND RANGE
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Ogden, Utah 84401

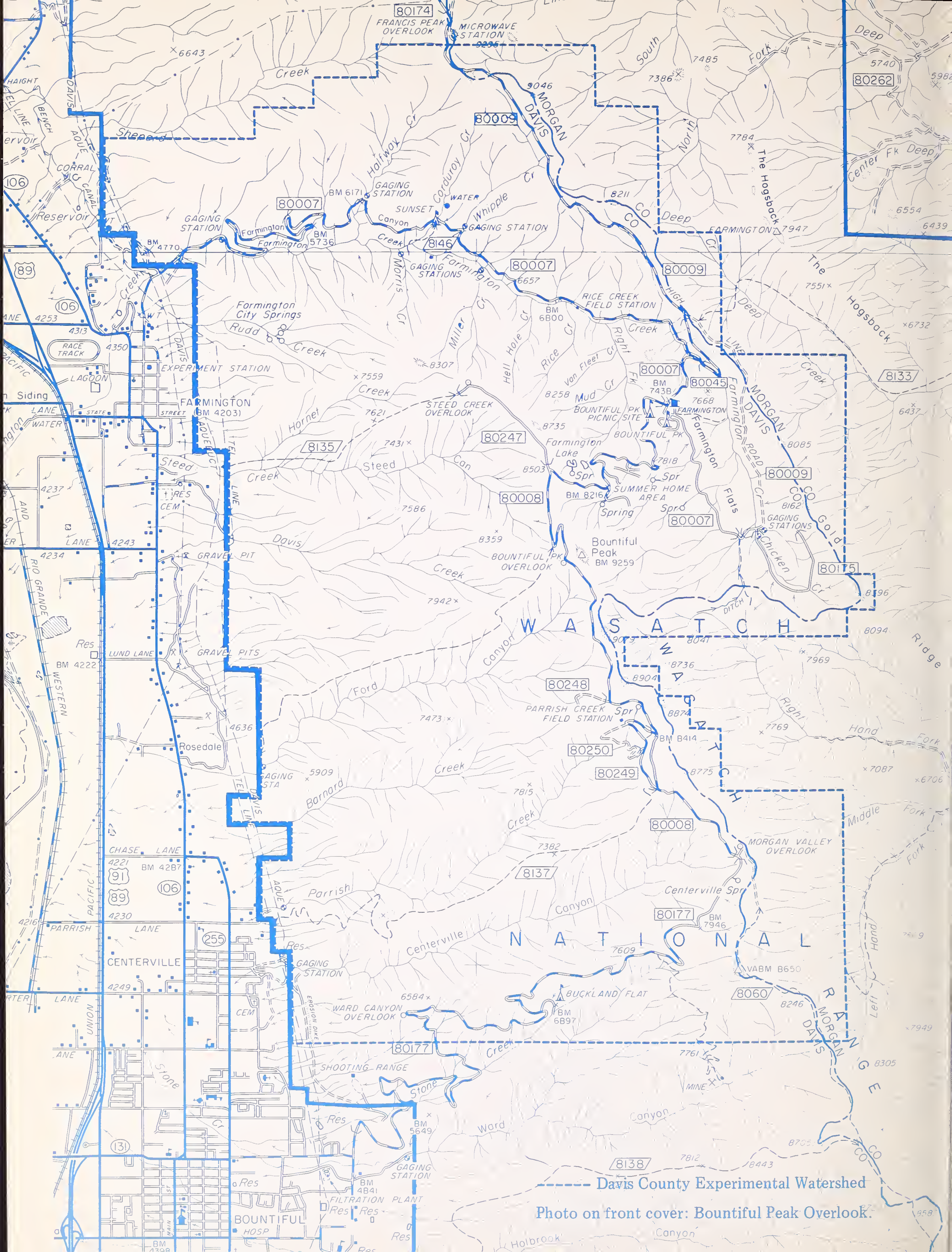

Photo on front cover: Bountiful Peak Overlook.

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INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Forest Service
U. S. Department of Agriculture
Ogden, Utah 84401
Robert W. Harris, Director

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Contents

Abstract

Articles reporting storm events, land management activities, and research conducted on the mountainous lands east of Farmington, Centerville, and Bountiful, Utah (now known as the Davis County Experimental Watershed) and general publications citing this area are annotated.

Introduction

The Davis County Experimental Watershed (DCEW), a portion of the Wasatch National Forest, was formally designated as a research area in 1953. However, this portion of Utah's Wasatch Mountains between Farmington and Bountiful served as an outdoor laboratory for the Intermountain Forest and Range Experiment Station since 1933, when what was called the Wasatch Research Center was established in Farmington. Here, and elsewhere in Utah, mud-rock floods, especially those that occurred in 1923 and in 1930, caused by intense summer rainstorms falling on denuded watersheds, resulted in changes of land use and in public attitude: specifically, overgrazing and abuse stopped; rehabilitation and protection of these valuable watersheds began.

The earlier publications cited in this bibliography describe the floods and events that led up to rehabilitation and research programs. Successful rehabilitation techniques and the control of overland flow and erosion are stressed in most of these earlier citations, which were published during the mid-1930's through the 1950's. Since then, there has been increasing research emphasis on water yield improvement; the tone of the more recent citations indicates this emphasis. Listed are 87 citations: the earliest was published in 1925; the latest in 1972. These are arranged alphabetically by author. A subject matter index is provided on page 16.

Knowledge from research conducted on the DCEW has influenced watershed management throughout the world. Successful development of rehabilitation measures, especially contour trenches on mountain lands, has been of international significance. Watershed research continues on this historically important outdoor laboratory. Hopefully, the results of current research will be as significant to future management as past results have been to current practices.

Bibliography

1. Anonymous. 1970. The effect of contour trenching. Utah Farmer, Nov. 5:12.

Streamflow data show that peak runoff is reduced by trenching but total volume produced during the year remains the same. A brief, popular account of research later reported in detail (43).

2. Bailey, Reed W. 1935. Shackling the mountain flood. Am. For. 41(3):101-104, 150.

Describes floods and the rehabilitation program carried out by the Civilian Conservation Corps on the Wasatch Mountains. Measures taken include protection from grazing, construction of terrace-trenches and check dams, and reseeding.

3. Bailey, Reed W. 1941. Land-erosion--normal and accelerated--in the semi-arid West. Am. Geophys. Union Trans. 22:240-250.

A geomorphological approach toward erosion and flood problems. Some watersheds have normally high rates of degradation; others low. Accelerated erosion and runoff have been induced on some areas by reduction and deterioration of the plant cover. Post Lake Bonneville geologic evidence is used to show the acceleration of erosion and sedimentation on Parrish and Ford drainages.

4. Bailey, Reed W. 1948. Geologic understanding and watershed management. Inter-Am. Conf. Conserv. Renewable Nat. Resour. Proc., Denver, Colo. Sect. IV:341-348.

A discussion of soil stability, sedimentation, and stream flow. Farmington Creek is an example of normal geologic rates of deposition being stepped up by man's misuse of the land.

5. Bailey, Reed W. 1948. Reducing runoff and siltation through forest and range management. J. Soil and Water Conserv. 3(1):24-31.

An illustrated article describing concepts from research and their application to different types of water runoff problems. Work at the Wasatch Research Center is mentioned on control of summer debris-floods.

6. Bailey, Reed W., and Charles A. Connaughton. 1936. In watershed protection. P. 303-339, in: The Western Range--a Great but Neglected Natural Resource. 74th U.S. Congr., 2d sess., S. Doc. 199.

Deals with preservation of satisfactory watershed conditions of rangelands. References to Davis County, Utah, demonstrate catastrophes caused by depleted range. In 1923 and again in 1930, floods and mud-rock flows exceeded anything that had occurred in that area for 20,000 years. The floods wrought damages in the valley communities equivalent to $1,245 per acre of denuded flood-source areas.

7. Bailey, Reed W., and Otis L. Copeland, Jr. 1960. Low flow discharges and plant cover relations on two mountain watersheds in Utah. I.A.S.H. Comm. Surf. Waters 51:267-278.

Records for 22 years of streamflow are used from two adjacent watersheds of contrasting use history. Centerville drainage had no plant cover depletion or floods. Parrish watershed produced mud-rock flows in 1930 following destruction of vegetation on headwater lands. Contour trenching and reseeding restored the vegetation on Parrish watershed before streamflow records were maintained. From Parrish and from Centerville 73% and 62%, respectively, of the annual discharge occurred in the April-June period. Effective control of summer storm floods in Parrish watershed was accompanied by a decrease of 2.7 inches of annual runoff over the 22-year period; 83% occurred in the first 11 years. Most decrease occurred during high flow months of March-May.

8. Bailey, Reed W., and Otis L. Copeland. 1961. Vegetation and engineering structures in flood and erosion control. Paper presented at 13th Congr. Int. Union For. Res. Org., Vienna, Austria. 23 p., illus.

Floods and erosion with emphasis on causes and control in the Intermountain region are discussed. Several examples are taken from the DCEW. Contour trenches are described.

9. Bailey, Reed W., and George W. Craddock. 1948. Watershed management for sediment control. Fed. Interagency Sedimentation Conf. Proc., Denver, Colo., p. 302-310.

Use of watersheds in the West, geologically normal sedimentation, stable soils on steep, well-vegetated slopes, and accelerated erosion through man's activities are discussed. Induced mud-rock floods in northern Utah are used as examples. Importance of vegetation is emphasized; on the Parrish Plots denuded areas yielded 24% to 43% of the rainfall as surface runoff, whereas the well-vegetated areas yielded less than 1%. Restoration of the Davis County flood-source areas is described.

10. Bailey, Reed W., George W. Craddock, and A. R. Croft. 1947. Watershed management for summer flood control in Utah. USDA Misc. Publ. 639, 24 p., illus.

The mud-rock floods in the Farmington to Centerville area were a sequel to watershed abuse. Rehabilitation of flood sources stopped flooding even though the treated areas received very intense rains.

11. Bailey, Reed W., and A. R. Croft. 1937. Contour-trenches control floods and erosion on range lands. Emergency Conserv. Work, For. Publ. 4, 22 p., illus.

A "how-to-do-it" description of the contour trench system for flood and erosion control. Examples are taken from the Davis County rehabilitation work. Instructions for analyzing problem areas and application of rehabilitation methods are given. Different types of trenches are described in detail.

12. Bailey, Reed W., C. L. Forsling, and R. J. Becraft. 1934. Floods and accelerated erosion in northern Utah. USDA Misc. Publ. 196, 21 p., illus.

Abnormal runoff and erosion caused floods along the west slope of the Wasatch Mountains during the summers of 1923 and 1930. These floods were unprecedented since the recession of Lake Bonneville. Overgrazing and fires on the watersheds disrupted the balance between plant cover and soil.

13. Cannon, Sylvester Q., and others. 1931. Torrential floods in northern Utah, 1930. Utah Agric. Exp. Stn. Circ. 92, 51 p., illus.

For Davis County a special flood commission recommended a restoration program consisting of restricted grazing, reseeding, restoration of plant cover, and increased fire protection on the watershed lands. Public ownership was recommended. The commission attributed many of the floods that occurred in 1930 to uncommonly heavy rainfall, steep topography and geological conditions, and scant vegetation on portions of the watersheds. They noted that scant vegetation was natural on some areas, but on many areas, such as those in Davis County, the sparse vegetation was the result of depletion of plant growth caused by overgrazing, fire, or overcutting of timber.

14. Clark, Stephen L. 1966. A new northern extension of range for *Penstemon palmeri* in Utah. Utah Acad. Sci., Arts and Letters Proc. 43(1):161. (Abstr.)

This species was collected along the road leading to Francis Peak. Several plants were found in a small area of disturbed sandy soil. *P. palmeri* frequently is found in southwestern Utah. Perhaps it was introduced into Farmington Canyon by some human visitor.

15. Copeland, Otis L. 1960. Watershed restoration. A photo-record of conservation practices applied in the Wasatch Mountains of Utah. J. Soil and Water Conserv. 15(3):105-120.

Cites the DCEW as a classic example of watershed restoration. Illustrations show the eroded and denuded conditions before treatment and the well-vegetated and stable conditions several years after treatment.

16. Copeland, Otis L., Jr. 1965. Water yield improvement. Paper presented to Utah Chapter Soil Conserv. Soc. Am., Salt Lake City, Jan. 15. 6 p.

A general account, citing many data, of water yield improvement needs and means of satisfying these needs through watershed research and management. Current and past work on the DCEW are cited.

17. Copeland, Otis L. 1969. Forest Service research in erosion control. Am. Soc. Agric. Eng. Trans. 12(1):75-79.

Thirteen research projects, divided among four experiment stations, directly studying erosion and its control are listed. Specific examples are cited. Past work on DCEW, especially that involving contour trenches, is mentioned.

18. Craddock, George W. 1946. Salt Lake City flood, 1945. Utah Acad. Sci., Arts and Letters Proc. 23:51-61.

A destructive flood occurred on August 19 in Salt Lake City. High intensity rainfall produced unprecedented debris-laden runoff, especially from an area burned in 1944. Nearby, on the DCEW, rainfall of recordbreaking intensity on the same night did not produce floods from these well-vegetated, rehabilitated slopes.

19. Craddock, George W. 1947. Watershed management and sediment control. Paper given at Assoc. West. State Eng., Boise, Idaho, p. 65-74.

The use of watershed lands is discussed. Induced mud-rock floods in northern Utah are used as examples. Effective restoration of the Davis County flood-source areas is described.

20. Craddock, George W. 1948. Insuring Utah's water supplies through watershed research. The Utah Mag. Sept., p. 14-15, 27-29.

The Great Basin Research Center at Ephraim, Utah, and the Wasatch Research Center at Farmington, Utah, established in 1912 and 1933, respectively, were developed to answer important watershed management questions. Information taken from these outdoor laboratories has been used to develop answers to some problems. Summer floods, how they were controlled, and continuing research are described.

21. Craddock, George W. 1960. Floods controlled on Davis County watersheds. J. For. 58(4):291-293.

Describes the history and summer mud-rock floods of Davis County, the determination of causes, and the development and application of remedial measures, which include contour trenches. The treated lands have been subjected to more than 300 summer rainstorms. No mud-rock floods have developed from any intensively treated watersheds. This rehabilitation has had little effect on water yields.

22. Crawford, Arthur L., and Fred E. Thackwell. 1930. Some aspects of the mudflows north of Salt Lake City, Utah. Paper presented at Utah Acad. Sci., Nov. 8, and at Utah Soc. Eng., Nov. 19. 12 p.

Describes debris floods of August 1930, especially those that the authors encountered at Willard, Farmington, and Centerville. They opined that climatic and geological conditions near Willard, Farmington, and Centerville would produce floods of this nature regardless of man's activities. Downstream channeling was recommended as the most feasible treatment.

23. Croft, A. R. 1935. Watersheds and the farmer. Utah Farmer 56(5):3, 14.

Illustrates the importance of watersheds and proper watershed management practices to the downstream user. Cites precipitation data by elevation, flood damages from mismanagement, and values of water.

24. Croft, A. R. 1936. Why all these floods? Utah Farmer 57(6):1, 3, 10-11.

A popular account of the floods and mud-rock flows that result from summer rainstorms on Utah mountain watersheds. Depleted plant cover was the usual cause.

25. Croft, A. R. 1944. Some recharge- and discharge-phenomena of north- and south-facing watershed lands in the Wasatch Mountains. Am. Geophys. Union Trans. 25:881-889.

Runoff from the two watersheds was the same from October through March. South-facing Whipple Creek peaked earlier in the spring. About 33 inches of precipitation fell in each basin; Miller yielded 51% of it, Whipple only 31%. The amount of water left in the snowpack when the soil mantle reached field capacity equaled total runoff from each watershed. Summer moisture deficits in the soil were maximum by October 9.

26. Croft, A. R. 1946. Some factors that influence the accuracy of water-supply forecasting in the Intermountain region. Am. Geophys. Union Trans. 27(3):375-388.

Water stored as snow is inadequate for water yield forecasting from Farmington watershed. Water storage in the soil, recharge of mantle moisture by October precipitation and by winter snow melting, loss of deep seepage, and spring rains give more accurate forecasts than snowpack moisture content alone. (For a discussion of this paper by M. T. Wilson, and a reply by Croft, see Am. Geophys. Union Trans. 28(3):484-491.)

27. Croft, A. R. 1946. A land-use management cycle. J. For. 44(11):819-822.

The Society of American Foresters' annual meeting featured an all-day excursion to the DCEW. The problems, the damages, and the watershed rehabilitation measures seen and discussed on the tour are briefly told.

28. Croft, A. R. 1948. Water loss by stream surface evaporation and transpiration by riparian vegetation. Am. Geophys. Union Trans. 29(2):235-239.

For the August-October period, evapotranspiration losses in Farmington Creek were about a third of the total streamflow. Analysis involved consideration of streamflow fluctuations that were diurnal, seasonal, caused by weather, or caused by freezing of leaves in late summer.

29. Croft, A. R. 1950. A water cost of runoff control. J. Soil and Water Conserv. 5(1):13-15.

Evapotranspiration and runoff studies on the DCEW (Parrish Plots) suggest that removal of aspen may be a feasible means of increasing seepage flow to the streams. Removal of aspen retained 3 to 4 inches of water in the soil.

30. Croft, A. R. 1959. A concept of erosion potential of mountain soils. J. Geophys. Res. 64 (8):1099. (Abstr.)

On the Wasatch Front, sediment increased from 0.0025 acre-foot/square mile/year in the recent geologic past to 6.25 AF/SMY (a 2500X increase) in this century; this increase was attributed to changes in vegetal cover followed by changes in the soil's hydrologic functioning during torrential rains.

31. Croft, A. R. 1962. Some sedimentation phenomena along the Wasatch Mountain front. J. Geophys. Res. 67(4):1511-1524.

Describes sediment from Bairs Creek from the time of Lake Bonneville to the present. This sediment consists of (1) silts and clays of lacustrine origin, (2) bouldery alluvium produced during the recession of Lake Bonneville, and (3) bouldery alluvium of historic times that is related to watershed abuse.

32. Croft, A. Russell. 1967. Rainstorm debris floods: a problem in public welfare. Univ. Ariz. Agric. Exp. Stn. Rep. 248, 36 p., illus.

A well-illustrated historical account of debris floods in the Intermountain area of the West. Discusses causes and prevention. Many examples cited occurred on the DCEW.

33. Croft, A. Russell, and Reed W. Bailey. 1964. Mountain water. USDA For. Serv. Intermt. Reg., 64 p., illus.

A semitechnical account of the history and importance of watershed management in the Intermountain region, where 75% of the water comes from National Forest lands. The function of watersheds, mantle breakdown, and repairing of damaged watersheds are discussed.

34. Croft, A. Russell, and Leonard W. McDonald. 1944. Centerville...a pattern for progress. Utah Farmer 64(5):3-4, 14, 20.

Describes how priceless streams flow from well-managed mountain land. These streams provide the foundation for man's activities in arid Utah valleys.

35. Croft, A. R., and Richard B. Marston. 1950. Summer rainfall characteristics in northern Utah. Am. Geophys. Union Trans. 31(1):83-95.

Frequency, depth, intensity, and areal extent of July-August cloudburst type rainfall are reported for seven Davis County watersheds. Records from 1936 to 1947 are used.

36. Croft, A. R., and L. V. Monninger. 1953. Evapotranspiration and other water losses on some aspen forest types in relation to water available for stream flow. Am. Geophys. Union Trans. 34(4):563-574.

Removal of aspen, leaving the herbaceous understory, reduced evapotranspiration from the Parrish Plots and increased the amount of water available for streamflow by 4 inches. Removal of the remaining herbaceous cover further increased the amount of water available to streams an additional 4 inches but resulted in an undesirable increase in summer runoff and soil loss.

37. Croft. A. R., and James P. Thorne. 1943. Some properties of Wasatch Mountain soils. Utah Acad. Sci., Arts and Letters Proc. 21:6. (Abstr.)

Describes the soils on the Farmington Creek watershed as coarse textured, high in organic matter, and acidic. Associates increased elevation with decreasing silt, organic matter, and pH. Reports that soils on eroded areas are coarser in texture and have 50% less organic matter than do the soils on uneroded areas.

38. DeByle, Norbert V. 1970. Soil freezing determined with four types of water-filled tubes. USDA For. Serv. Res. Note INT-127, 8 p., illus.

Periodic determinations of soil temperatures and ice column depths in tubes were made at three sites in northern Utah. At the head of Halfway Creek on the DCEW, the 0° C. isotherm went down to 41 inches in the soil on this exposed mountain ridge. Steel tubing, used as access tubes for neutron soil moisture probes, proved as good as steel or plastic pipe as casings for frost meter tubes.

39. DeByle, Norbert V., Robert S. Johnston, Ronald K. Tew, and Robert D. Doty. 1969. Soil moisture depletion and estimated evapotranspiration on Utah watersheds. Paper presented at Int. Conf. on Arid Lands in a Changing World, Tucson, Ariz., June 3-13. 14 p., illus.

Evapotranspiration is the principal component of the hydrologic cycle modified by watershed managers to affect timing or quantity of streamflow. Where no water percolates through the soil during the growing season, measured soil moisture depletion plus summer precipitation give an estimate of actual evapotranspiration. This procedure was applied on 14 sites (five on DCEW) representing 10 vegetation types. Annual evapotranspiration amounts from 5.12 inches (from sagebrush-grass and grass-forb) to 24.15 inches (from mature aspen) were estimated.

40. Doty, Robert Dean. 1970. Hydrologic effects of contour trenching on some aspects of streamflow from a pair of watersheds in Utah. Unpubl. M.S. thesis, Utah State Univ. 70 p., illus.

Streamflow from two drainages was evaluated with respect to changes in distribution and volume following contour trenching 15% of one of them, Halfway Creek, in 1964. Neither volume nor distribution of annual streamflow, spring period streamflow, or low period streamflow were changed by the trenching.

41. Doty, Robert D. 1970. Influence of contour trenching on snow accumulation. J. Soil and Water Conserv. 25(3):102-104.

The trenches are on the upper 15% of Halfway Creek on a windswept southwest exposure where snow redistribution is important. Trenches increased snow accumulation slightly; this appeared to contribute more to revegetation than to water yield.

42. Doty, Robert D. 1970. A portable, automatic water sampler. Water Resour. Res. 6(6):1787-1788.

The sampler is lightweight, battery powered, and automatically bottles 16 samples at preset time intervals. It was designed for and initially tested on DCEW gaged drainages.

43. Doty, Robert D. 1971. Contour trenching effects on streamflow from a Utah watershed. USDA For. Serv. Res. Pap. INT-95, 19 p., illus.

After measuring streamflow from two DCEW drainages (Halfway and Miller) for 12 years, some 15% of one, Halfway, was contour trenched. The 4 years of posttrenching records show that peak spring and peak summer storm flows were reduced. However, annual water yields, base flow, and snowmelt runoff were not significantly altered.

44. Doty, Robert D. 1972. Soil water distribution on a contour-trenched area. USDA For. Serv. Res. Note INT-163, 6 p., illus.

Some redistribution of soil water occurred following trenching in the Halfway Creek watershed. However, soil water conditions were not sufficiently changed to alter water yields. A reduction in water use from trench bottoms was offset by an increased loss from the cut-bank and trench fills. No change occurred between trenches.

45. Doty, Robert D., and Robert S. Johnston. 1967. A heating system for stream gaging stations. J. Soil and Water Conserv. 22(6):251-252.

A cover and propane heating apparatus were developed to prevent icing in a 3-foot "H" type flume and adjoining stilling well. The system has been successfully used in areas where mean monthly temperatures are as low as 12° F.

46. Farmer, Eugene E., and Joel E. Fletcher. 1971. Precipitation characteristics of summer storms at high-elevation stations in Utah. USDA For. Serv. Res. Pap. INT-110, 24 p., illus.

Data from 25 precipitation intensity stations, with 10 or more years of record, were analyzed for consistency, precipitation zones, intensity-duration-frequency, 24-hour depths, monthly depths and number of storms, hour of occurrence, and duration. The stations were at the Great Basin Experimental Range near Ephraim and on the DCEW. Total rainfall depth increases with elevation but storms become shorter. There is a trend toward reduced intensities with increasing elevation, too. Convective storms as well as weak cold fronts caused most summer rainfall on the DCEW.

47. Farmer, Eugene E., and Joel E. Fletcher. 1972. Rainfall intensity-duration-frequency relations for the Wasatch Mountains of northern Utah. Water Resour. Res. 8(1):266-271.

Results of data analyses from 14 precipitation stations on the DCEW at altitudes of 4,350-9,000 feet are presented. Each station has 10 or more years of record from May 1 to October 31. Analyses include record consistency, definition of local precipitation zones, and intensity-duration-frequency characteristics. Urban encroachment and the paving of areas within the lowest precipitation zone, where the greatest annual rainfall intensities can be expected, may produce localized flooding.

48. Farmer, Eugene E., and Joel E. Fletcher. 1972. Some intra-storm characteristics of high-intensity rainfall bursts. P. 525-531, in: Distribution of Precipitation in Mountainous Areas. Vol. 2. Geilo Symp., Norway. World Meteorol. Org., Geneva.

Analyses of data from 25 stations in central and north-central Utah include intrastorm timing and number of bursts, distribution of storm rainfall by 10% of storm duration, and relationship between depth of total storm rainfall and depth of burst rainfall. More than 50% of the total storm rainfall depth occurs in 25% of the storm period; usually more than half of the total depth is delivered as burst rainfall. Bursts occur most frequently in the first quarter of the storm period. Design data are presented for storms that contain a burst of 10 minutes or longer with return periods of 2 and 10 years.

49. Forsling, C. L. 1932. Erosion on uncultivated lands in the Intermountain Region. Sci. Mon. 34:311-321.

Data from the Great Basin Experimental Station, Davis County watershed, and granitic soils in Idaho show that vegetation prevents accelerated soil erosion and summer floods. Given the opportunity, vegetation will heal barren gullies and lessen erosion and floods.

50. Gifford, Gerald F. 1964. Aspen root and top growth: field observations of roots; response of roots and tops to moisture, temperature, light intensity, and soil type. Unpubl. M.S. thesis, Utah State Univ., 109 p., illus.

On the DCEW, two clone groups of nine and 15 trees, respectively, in sandy loam soil, and one group of five trees in clay were identified through use of a tracer and then excavated. Also, employing an environmental chamber, the effects of three soils, two light intensities, and three temperature regimes on root and top growth of suckers were measured.

51. Gifford, Gerald F. 1966. Aspen root studies on three sites in northern Utah. Am. Midl. Nat. 75(1):132-141.

Aspen root distribution was studied on the DCEW and near Logan, Utah. Nine of the 29 trees excavated had no vertical adventitious roots and 12 had no lateral root development. Seven existed on only the parent root, and six others had only a single adventitious root. Root depth exceeded 50 inches in clay and 114 inches in sandy loam; the majority of roots were in the top 4 ft. The maximum length of parent root between terminal ramets was 113 ft. Parent root depths ranged from 0.2 to 3.3 ft. but all ramets originated at depths less than a foot.

52. Glasser, Stephen P. 1969. Analysis of long-term streamflow patterns on two Davis County experimental watersheds in Utah. Unpubl. M.S. thesis, Utah State Univ. 94 p., illus.

Water yields from densely-vegetated, north-facing Miller Creek were more variable for daily, monthly, seasonal, and annual flows than yields from southwest-facing, brushy slopes in Halfway Creek. On both watersheds the snowmelt runoff season was 65 days; this season began 25 days earlier (March 29) on Halfway Creek. About 57% of the 19.4 inches mean annual flow from Halfway Creek and 68% of the 17.9 inches mean annual flow from Miller Creek occurred during snowmelt runoff.

53. Hart, George E. 1969. A semiautomatic method for reducing streamflow records. J. Soil and Water Conserv. 24(2):63-65.

The traditional method of reducing streamflow data is adapted to computers. The system was modified for four stream gages on the DCEW.

54. Johnston, Robert S. 1969. Aspen sprout production and water use. USDA For. Serv. Res. Note INT-89, 6 p., illus.

Sprouting and moisture depletion on plots in the Chicken Creek drainage were compared after the following treatments: (1) Clearcut; (2) clearcut, stumps sprayed with sodium arsenite; (3) basal injection of sodium arsenite; and (4) unaltered control. For two years, clearcut plots had the most sprouts and basal injection plots had the least, but after 4 years the numbers of sprouts were about equal. Clearcutting reduced moisture depletion by 3 to 4 inches of water in a 6-ft. profile.

55. Johnston, Robert S. 1970. Evapotranspiration from bare, herbaceous, and aspen plots: a check on a former study. Water Resour. Res. 6(1):324-327.

A neutron meter was used to measure soil moisture depletion to a depth of 9 ft. under bare, herbaceous, and aspen-herbaceous cover. The results substantiate Croft and Monninger's data (36) concerning comparative water savings by vegetative manipulation. Removing aspen can reduce evapotranspiration by 6 inches per year from a 9-ft. soil profile.

56. Johnston, Robert S. 1971. Rainfall interception in a dense Utah aspen clone. USDA For. Serv. Res. Note INT-143, 4 p.

Some 10.3% of gross summer rainfall was intercepted by a scrubby, high-elevation aspen stand; over 4 years, this loss totaled only 1.43 inches. Stemflow from the aspen was only 1.4% of gross rainfall.

57. Johnston, Robert S., and Robert D. Doty. 1972. Description and hydrologic analysis of two small watersheds in Utah's Wasatch Mountains. USDA For. Serv. Res. Pap. INT-127, 53 p., illus.

Describes climate, geology, soils, and vegetation of the two Chicken Creek watersheds in the high-elevation aspen type in the upper reaches of the Farmington Creek drainage. Precipitation, soil-water use, evapotranspiration, and quantity and quality of streamflow are illustrated and discussed. This thorough inventory will permit a sensitive, multiresource analysis of watershed treatment.

58. Johnston, Robert S., Ronald K. Tew, and Robert D. Doty. 1969. Soil moisture depletion and estimated evapotranspiration on Utah mountain watersheds. USDA For. Serv. Res. Pap. INT-67, 13 p., illus.

Soil moisture depletion was measured on 14 sites (five on the DCEW) representing 10 vegetation types. Aspen sprouts utilized up to 4.5 inches less water from 6 ft. of soil than mature aspen; Gambel oak sprouts utilized up to 1.15 inches less water than mature oak. Converting aspen to grass reduced water consumption up to 7.59 inches from a 9-ft. depth.

59. Lobenstein, Henry. 1948. Flood control surveys propose safeguards for Utah's farmlands, industries, and homes. The Utah Mag. Sept. p. 22-23, 32-34.

Traces the history of flooding and flood control work in Utah, mentioning Davis County as a prime example of successful search for causes and application of good remedial measures.

60. Marston, Richard B. 1949. Effect of vegetation on rainstorm runoff. Utah Acad. Sci., Arts and Letters Proc. 26:144. (Abstr.)

Reports data from Parrish Plots for 1936 to 1948. Aspen-herbaceous plots yielded less than 1% runoff during 132 storms; those on which annual herbs were depleted yielded up to 40%. Ten years of natural revegetation reduced storm runoff to 5%. Conversely, denudation of aspen-herbaceous cover resulted in a 28-fold increase in storm runoff.

61. Marston, Richard B. 1952. Ground cover requirements for summer storm runoff control on aspen sites in northern Utah. J. For. 50(4):303-307.

Reports data from 1936 to 1949 from the Parrish Plots: 146 summer storms were recorded, 36 of which caused runoff. Treatments were applied in 1947. Mulched and seeded plots as well as plots invaded by aspen stabilized and produced less runoff; a formerly well-vegetated, nonflood-source plot eroded severely after it was denuded. Erosion was negligible when 5% or less of the rainfall ran off as overland flow. For adequate protection, 65% ground cover appears necessary on aspen watersheds of Utah.

62. Marston, R. B. 1953. Guide to Davis County Experimental Watershed, Farmington Utah. USDA For. Serv., Intermt. For. and Range Exp. Stn., 19 p., illus.

Gives historical highlights and a self-guided tour. A popular account, it emphasizes the plots at the head of Parrish Canyon.

63. Marston, Richard B. 1955. Infiltration rates of two waterspreading projects, Davis County, Utah. USDA For. Serv., Intermt. For. and Range Exp. Stn. Res. Note 20, 5 p., illus.

Surplus water was diverted into a basin from Centerville Creek from 1937 to 1953. In 1938, infiltration was 39 inches per day; in 1942, it was 28 inches per day. Measurements showed no change in ground water. From 1941 to 1947, approximately 1,941 acre feet of water was spread in the Bountiful project. The infiltrated water returned to the surface due to a clay lens. Water spreading may be useful in storing water but should be undertaken after study of underlying strata indicates the water will sink into basins where it can be recovered.

64. Marston, Richard B. 1956. Air movement under an aspen forest and on an adjacent opening. J. For. 54(7):468-469.

Measurements were obtained during 1948 at the head of Parrish Canyon. One anemometer was placed at a 2-ft. height on each site, above the herbaceous vegetation, but under the dense aspen canopy of 12-ft. height. Air movement was 1,799 miles under aspen; in the open, it was 8,226 miles, or 4.57 times as much.

65. Marston, R. B. 1958. The Davis County Experimental Watershed story. USDA For. Serv., Intermt. For. and Range Exp. Stn., 37 p., illus.

A well-illustrated popular account of the history, geology, vegetation, and watershed research of DCEW: a self-guided tour.

66. Marston, Richard B. 1958. Parrish Canyon, Utah: a lesson in flood sources. J. Soil and Water Conserv. 13(4):165-167.

Parrish Creek drainage was stable before settlement; erosion did not exceed 0.0025 acre-foot per square mile per year. After settlement, grazing and burning rendered slopes unstable and increased sedimentation a thousandfold. Data taken from plots at this site provide proof of the efficacy of vegetal cover in preventing flood runoff and erosion.

67. Marston, Richard B. 1963. Some comparative hydrologic characteristics of aspen and mountain brush communities on steep mountain watersheds in northern Utah. Unpubl. Ph.D. diss., Utah State Univ., 84 p., illus.

Plots were at the headwaters of Farmington, Ford, and Parrish drainages. Observations were made on (a) vegetational composition and coverage, (b) soil, and (c) weather. Percent ground cover, canopy volume below 4.5 ft. tall, and depth of litter were greatest under brush. Addition of overstory increased the volume of the aspen canopy to three times that of the brush. Bulk density of the soil was greater under the brush than under the aspen canopy. Brush used more water than aspen. Estimated water for streamflow agreed with measured streamflow.

68. Marston, Richard B., and A. Russell Croft. 1965. The watershed complex. I.A.S.H. Bull. X^{e} Année N^{o} 4:20-24.

Describes the complex of soils, vegetation, and water that interact on a watershed.

69. Marston, Richard B., and Odell Julander. 1961. Plant cover reductions by pocket gophers following experimental removal of aspen from a watershed area in Utah. J. For. 59 (2):100-102.

Pocket gophers reduced the perennial cover after aspen was removed from a plot in Parrish Canyon. Annuals increased, but total cover may have become insufficient to protect against erosion. Gopher mounds were twice as numerous on the plot on which the aspen was removed than on the control area.

70. Meeuwig, Richard O. 1970. Infiltration and soil erosion as influenced by vegetation and soil in northern Utah. J. Range Manage. 23 (3):185-188.

Infiltration and soil stability on Parrish and Farmington drainages were investigated under simulated rainfall. Results emphasize the importance of vegetation and litter cover in maintaining infiltration capacity and soil stability. Infiltration is also affected by soil bulk density, aggregation, and moisture content.

71. Meeuwig, Richard O. 1970. Sheet erosion on intermountain summer ranges. USDA For. Serv. Res. Pap. INT-85, 25 p., illus.

Simulated rain was applied to plots on mountain rangeland in Utah, Idaho, and Montana. The DCEW was one of three sites in Utah. Soil erosion depended on proportion of soil protected from direct raindrop impact. Organic matter favored stability of fine-textured soils. Gives regression equations which can be used to estimate potential erosion.

72. Monninger, L.V. 1950. Rainfall interception by aspen and herbaceous vegetation. Utah Acad. Sci., Arts and Letters Proc. 27:73. (Abstr.)

Interception by aspen-herbaceous and herbaceous cover averaged 35% and 24%, respectively, during 20 rainstorms on the Wasatch front. Stemflow was negligible. Storm size and amount of rainfall intercepted were significantly correlated.

73. Noble, Edward L. 1963. Sediment reduction through watershed rehabilitation. Paper presented at the Fed. Interagency Sediment. Conf., Jackson, Miss. 29 p., illus.

Methods of stabilizing soil on mountain watersheds include intensive management, revegetation, and contour trenching. Contour trenching is fully described; it is most effective but not a panacea. Examples are drawn from DCEW.

74. Olson, O. C. 1949. Relations between soil depth and accelerated erosion on the Wasatch Mountains. Soil Sci. 67(6):447-451.

Data were taken from six watersheds, including Farmington. Deep, friable soils occupy 71% of the area studied. Moderate sheet erosion was found on 16% of the area, severe sheet erosion on 6%. Virtually all accelerated erosion was under sagebrush, grasses, forbs, or low-density mountain brush. Soils having friable surfaces underlain by tight clay or bedrock at shallow depths occupied only 20% of the area, but 85% of the severe erosion occurred on such soils.

75. Paul, J. H., and F. S. Baker. 1925. The floods of 1923 in northern Utah. Univ. Utah Bull. 15(3), 20 p., illus.

Describes the debris floods that occurred on August 13 from Willard and Farmington Canyons. Precipitation on bare or denuded areas of these and other canyons of the Wasatch Mountains produced damaging floods. The authors conclude that rainfall is never intense enough to cause floods where climatic conditions favor growth of dense mountain vegetation, except where key areas on ridges and canyon heads are naturally barren or have been denuded by overgrazing or fire. They recommend public ownership and restriction of grazing.

76. Peck, Eugene L. 1967. Influences of exposure on pan evaporation in a mountainous area. Ph.D. diss. and joint rep. by U.S. Dep. Comm. ESSA and Utah State Univ. Water Res. Lab., 132 p., illus.

Evaporation stations were operated on the DCEW during 1962 through 1966. Daily observations were taken from 17 sites. Relationships of climatic parameters, elevation, and exposure to pan evaporation were tested.

77. Peck, Eugene L., and Dale J. Pfankuch. 1963. Evaporation rates in mountainous terrain. I.A.S.H. Comm. for Evap. Publ. No. 62:267-278.

An investigation was undertaken on the DCEW to determine effects of elevation, topography, and exposure on evaporation. Daily readings were taken from 13 evaporation stations at sites ranging from 4,400 to 9,000 ft. elevation. Analyses include comparison of rates from pairs of stations near the same elevation for daytime versus nighttime. Effect of drainage winds is noted. Mean daily evaporation ranged from 0.206 to 0.333 inch.

78. Petersen, Dan Lloyd. 1954. Reinventory of surface soil and plant characteristics, Morris watershed. Unpubl. M.S. thesis, Univ. Utah. 48 p., illus.

After cessation of grazing in 1937, the watershed was inventoried in 1939 and reinventoried in 1953. Litter depth increased. In the lower portions of this drainage, vegetation density increased; in the upper portions, it decreased. Both composition and density of vegetation were undergoing changes in the upper portions.

79. Schultz, John D. 1964. Field correlation of two neutron-scattering soil moisture meters. USDA For. Serv. Res. Note INT-21, 7 p., illus.

Operation of two neutron soil moisture probes was compared on the DCEW. Correlation curves indicate the best positioning of these probes in the access tube when one is used in lieu of the other.

80. Schultz, John D. 1964. Functional root connections in trembling aspen clones of the Wasatch Range. Paper presented at AIBS Meet. Boulder, Colo. Also, Abstr. in Ecol. Soc. Am. Bull. 45(3):91.

Use of techniques developed in Michigan for tracing root connections in aspen revealed a greater extensiveness of the phenomenon on the DCEW. Using eosine dye tracer, 31 stems were found connected into one group. Use of sodium arsenite resulted in locating a group of 43 stems.

81. Tew, Ronald K. 1966. Soil moisture depletion by Gambel oak in northern Utah. USDA For. Serv. Res. Note INT-54, 7 p., illus.

Gambel oak withdrew 11 to 13 inches of water from 8 ft. of soil during the growing season. Depletion early in the season occurs mainly in the upper 4 ft; later in the season, it occurs lower. Precipitation provides sufficient moisture to fully recharge the soil profile after each growing season on this south-facing slope east of Centerville.

82. Tew, Ronald K. 1969. Converting Gambel oak sites to grass reduces soil-moisture depletion. USDA For. Serv. Res. Note INT-104, 4 p.

Replacement with grasses on a plot east of Centerville reduced soil moisture depletion by 3.09 inches. Most of the savings occurred in the lower half of the 8-ft. profile.

83. Tew, Ronald K., Norbert V. DeByle, and John D. Schultz. 1969. Intraclonal root connections among quaking aspen trees. Ecology 50(5):920-921.

Three tracer solutions were applied to 46 aspen clones on the DCEW. As many as 43 stems were connected on a common root system. The maximum distance between tracer donor and receptor stems was 55 ft. Number of stems connected was not related to soil properties tested.

84. USDA Forest Service. 1968. Islands of green. USDA For. Serv. Intermt. Reg. 20 p., illus.

Summarizes material published in another popular documentary, "Mountain Water" (33).

85. USDA Forest Service. 1970. Your tour of Davis County Experimental Watershed. USDA For. Serv. Intermt. For. and Range Exp. Stn. (Brochure and map.)

Discusses the history of the watershed, past and present research, floras, faunas, and other features. (A popular, illustrated, self-guided tour of the DCEW.)

86. Walker, Clive H. 1970. Estimating the rainfall-runoff characteristics of selected small Utah watersheds. Unpubl. M.S. thesis, Utah State Univ. 120 p., illus.

Data from three watersheds (Halfway and Morris on the DCEW, and Alpine Meadows near Ephraim) were used. Ratios of runoff to precipitation were compared to computed and estimated runoff curve numbers. Watershed lag characteristics were estimated.

87. Winters, Wayne Street. 1954. Reinventory of soil and plant characteristics of Miller watershed. Unpubl. M.S. thesis, Univ. Utah, 95 p., illus.

After cessation of grazing in 1937, the watershed was inventoried in 1939 and again in 1953. There was a small increase in vegetal cover, largely through increase in shrubs below 7,600 ft. elevation. Litter increased and erosion runoff potential decreased. The author concludes that long periods of time are necessary for high elevation range to recover through the prevention of grazing alone.

ADDENDUM

Hull, A. C., Jr. 1973. Duration of seeded stands on terraced mountain lands, Davis County, Utah. J. Range Manage. 26(2):133-136.

From 1936 to 1939, in northern Utah, 37 species were seeded on 14 areas of depleted and terraced mountainous rangelands. Most stands decreased; in 1971 only smooth brome, tall oatgrass, intermediate wheatgrass, and red fescue had fair to excellent stands. Native grasses, forbs, shrubs, and trees have reinvaded the seeded areas.

Subject Index

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Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field Research Work Units are maintained in:

- Boise, Idaho
- Bozeman, Montana (in cooperation with Montana State University)
- Logan, Utah (in cooperation with Utah State University)
- Missoula, Montana (in cooperation with University of Montana)
- Moscow, Idaho (in cooperation with the University of Idaho)
- Provo, Utah (in cooperation with Brigham Young University)
- Reno, Nevada (in cooperation with the University of Nevada)

Back cover photo shows Halfway Creek contour trenches.